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BIOMETRY.—*The growth of mixed populations: Two species competing for a common food supply.*[1] ALFRED J. LOTKA, New York, N. Y.

The general analysis of the growth of mixed populations of any number of species in mutual interdependence *of any kind* which has been given by the writer in prior publications[2] covers many special cases. It is of interest to note how it applies to and readily furnishes the solution of a special case that has since been separately discussed by Volterra,[3] namely that of two species competing for a common food supply.

Volterra, following in this respect well-established lines familiar from prior literature,[4] starts out from the supposition that, in the absence of restraining influences, the rate of growth of a population would be proportional to the existing population thus

$$\frac{dN}{dt} = rN \tag{1}$$

resulting in an exponential (Malthusian) law of population growth; but that the natural limitations of the food supply convert the coefficient r into a diminishing function of N. In the simplest case this would be a linear function, so that we should have

$$\frac{dN}{dt} = r_0 N (1 - phN) \tag{2}$$

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[1] Received August 12, 1932.

[2] Among these may be mentioned Physical Review, 1912, **34**: 235; Proc. American Academy Arts and Sciences **55**: 137; 1920; American Journal of Hygiene **3**: January Supplement; 1923; Elements of Physical Biology, Baltimore, 1925. This last also contains references to the author's other publications relative to this subject.

[3] Memorie della R. Acad. Nazion. dei Lincei 1926 ser 6, vol. 2, part 3, page 5; *Leçons sur la théorie mathématique de la lutte pour la vie*, Paris, Gauthiers—Villars, 1931, page 9.

[4] See, for example, LOTKA, A. J., Elements of Physical Biology, 1925, page 64.

where ph is a constant which I have written as the product of two constants for reasons that will appear presently. Equation (2) is simply the Verhulst-Pearl law of population growth, which, as we know, has been found to fit very acceptably a number of observed examples of population growth.

Now, when two populations compete for a common food supply, Volterra writes, essentially,

$$\left.\begin{aligned} \frac{dN_1}{dt} &= r_1 N_1 \{1 - p_1 (h N_1 + k N_2)\} \\ \frac{dN_2}{dt} &= r_2 N_2 \{1 - p_2 (h N_1 + k N_2)\} \end{aligned}\right\} \tag{3}$$

a system of equations that may be regarded as an almost self-evident extension of the equation (2), except that one may question why the same constants h, k appear in the two equations. We shall take up this question later. For the present we shall accept Volterra's original setting. He does not solve his equations, but discusses certain fundamental properties of the functions defined by them. As a matter of fact, by the general method set forth in my prior publications, a solution is readily obtained in series form, and at the same time the conclusions reached by Volterra drop out very readily, together with further information which is not found in his discussion.

We will proceed as follows. Volterra's equations are of the form

$$\left.\begin{aligned} \frac{dN_1}{dt} &= a_1 N_1 + a_{11} N_1^2 + a_{12} N_1 N_2 \\ \frac{dN_2}{dt} &= a_2 N_2 + a_{22} N_2^2 + a_{21} N_1 N_2 \end{aligned}\right\} \tag{4}$$

Equilibria. A stationary state occurs whenever $\frac{dN_1}{dt}$ and $\frac{dN_2}{dt}$ both vanish together. This defines three possible equilibria (to be more exact, stationary states) as follows:

$$a.)\ N_1 = 0 \quad N_2 = 0 \tag{5}$$

$$b.)\ N_1 = 0 \quad N_2 = -\frac{a_2}{a_{22}} = \frac{1}{p_2 k} \tag{6}$$

$$c.)\ N_2 = 0 \quad N_1 = -\frac{a_1}{a_{11}} = \frac{1}{p_1 h} \tag{7}$$

If the coefficients a are constants, there are no other equilibria within real finite values of N_1, N_2.

Stability of Equilibrium: 1. *At Origin.* To determine the nature of the equilibrium at the origin ($N_1 = 0, N_2 = 0$) we form the characteristic equation of the linear terms in equations (4), that is,

$$\begin{vmatrix} a_1 - \lambda & 0 \\ 0 & a_2 - \lambda \end{vmatrix} = 0 \tag{8}$$

which gives

$$\begin{aligned} \lambda_1 &= a_1 \\ \lambda_2 &= a_2 \end{aligned} \tag{9}$$

Now both a_1 and a_2, from the nature of things, are positive quantities, since the case of real interest is that in which each species is viable separately under the prevailing conditions. Hence both roots of the characteristic equation are positive, and the equilibrium at the origin is unstable.

2. *At Second Equilibrium.* To examine the character of the second equilibrium, we transform the equations (4) to a new origin by writing

$$N_1 = N_1 \tag{10}$$

$$n_2 = N_2 + \frac{a_2}{a_{22}} \tag{11}$$

we thus obtain

$$\left.\begin{aligned} \frac{dN_1}{dt} &= \left(a_1 - \frac{a_{12}\, a_2}{a_{22}}\right) N_1 + a_{11}\, N_1^2 + a_{12}\, N_1\, n_2 \\ \frac{dn_2}{dt} &= -\, a_2\, n_2 - \frac{a_{21}\, a_2}{a_{22}} N_1 + a_{22}\, n_2^2 + a_{21}\, N_1\, n_2 \end{aligned}\right\} \tag{12}$$

And, forming the characteristic equation, we find here

$$\begin{vmatrix} \left(a_1 - \frac{a_{12}\, a_2}{a_{22}}\right) - \lambda & 0 \\ -\frac{a_{21}\, a_2}{a_{22}} & -\, a_2 - \lambda \end{vmatrix} = 0 \tag{13}$$

or, in our original notation,

$$\begin{vmatrix} r_1\left(1 - \frac{p_1}{p_2}\right) - \lambda & 0 \\ -r_2\frac{h}{k} & -r_2 - \lambda \end{vmatrix} = 0 \qquad (14)$$

from which it is seen that the equilibrium is stable if, and only if

$$r_1\left(1 - \frac{p_1}{p_2}\right) < 0 \qquad (15)$$

i.e., if

$$p_2 - p_1 < 0 \qquad (16)$$

3. *At Third Equilibrium.* By the same reasoning we find that the third equilibrium is stable if, and only if

$$p_1 - p_2 < 0 \qquad (17)$$

It will be seen that, except in the special[5] case that $p_2 = p_1$, one of the two equilibria must be stable, the other unstable.

When p_2 is not equal to p_1, it is, for reasons of symmetry, immaterial to which of the two coefficients we ascribe the greater value. Let us, then, write

$$p_2 < p_1 \qquad (18)$$

so that the second equilibrium is the stable one,

i.e. $\qquad N_1 = 0 \qquad N_2 = \dfrac{1}{p_2 k}$

The general solution of the system of equations (12) can be written in the form of exponential series

$$N_1 = \Sigma P_{rs} e^{(r\lambda_1 + s\lambda_2)} \qquad N_2 = \Sigma Q_{rs} e^{(r\lambda_1 + s\lambda_2)} \qquad (19)$$

Numerical example. For the sake of obtaining a visual presentation of the form of the functions defined by the differential equations (3), (4), (12), and their series solution (19), several numerical examples were worked, of which the following is here selected for reproduction in the accompanying graph Figure 1. The values given to the various

[5] This special case, as Volterra has shown, can be integrated in finite terms. It is, however, of minor interest, since such an exact relation between the coefficients p_1 and p_2 represents, in concrete cases, an infinitely improbable condition.

constants in this example were arbitrary, except that in order to establish some contact with a concrete case, the values of the exponent λ_1 and the ultimate population N_∞ of the one species were those actually observed in the human population in the United States.

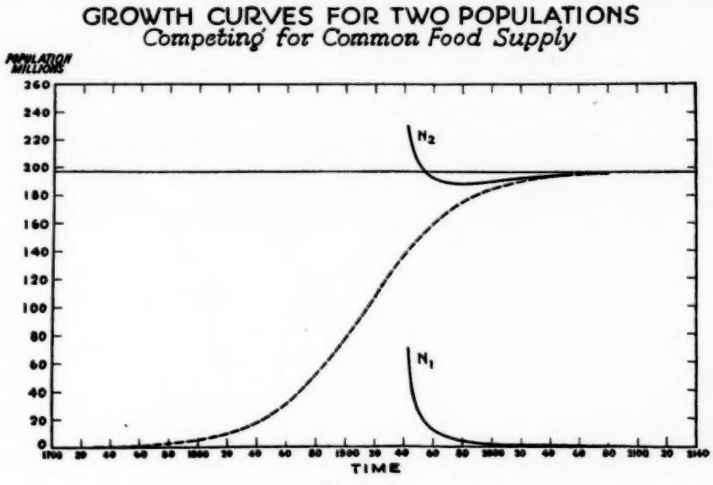


Figure 1.

The following is a table of the numerical values[6] of the several constants in this example:

h	20	p_1	1/1,315,153,333
k	10	p_2	1/10 × 197,273,000
r_{01}	0.10	λ_1	−0.03134
r_{02}	0.03134	λ_2	−0.05
P_{10}	−986,365.	Q_{10}	0.0
P_{01}	+100,000.	Q_{01}	29,770.
P_{02}	+102.85	Q_{02}	+72.228
P_{03}	+0.13084	Q_{03}	+0.14360
P_{04}	+0.00018325	Q_{04}	+0.00026977
P_{11}	1,706.5	Q_{11}	−712.43
P_{21}	+19.762	Q_{21}	+10.306
P_{12}	−3.1083	Q_{12}	−2.5999
P_{31}	−0.19113	Q_{31}	−0.11656
P_{22}	+0.056626	Q_{22}	+0.053969
P_{13}	−0.0056759	Q_{13}	−0.0069826

P_{20} + 491.83 P_{30} − 24.66 P_{40} 0.1233

[6] A considerable number of significant figures has been retained in these constants and throughout the computations, in order to furnish an arithmetical check on the series solution (19). This check was obtained by substituting the solution (19) separately in the left hand member and the right hand member of equations (4) or (12). In the absence of a special investigation of the conditions of convergence of the series (19) this arithmetical check is necessary, and was found to be well satisfied within the limits of the curves shown in Figure 1.

It will be seen that one of the two populations, in the circumstances to which the graph in Fig. 1 relates, at first diminishes, presently turns the corner, and then increases, approaching a certain straight line asymptotically; the other population diminishes continually and approaches zero. Thus one competitor drives the other out completely. This last point is one of the results given by Volterra[7] who, however, does not give any method for tracing the actual integral curve in detail.

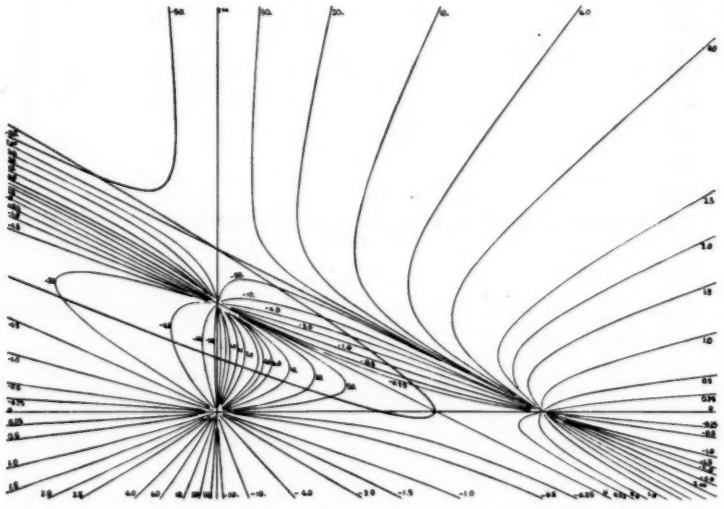


Figure 2.

Another graph, which is particularly instructive, is prepared by eliminating the independent variable t from the two equations (4), and writing

$$\frac{dN_1}{dN_2} = \frac{f_1(N_1, N_2)}{f_2(N_1, N_2)} \tag{20}$$

where f_1 and f_2 are quadratic functions of N_1 and N_2. The locus of all

[7] A similar conclusion had been previously reached by J. B. S. HALDANE regarding the competition between two Mendelian phenotypes. Trans. Cambridge Philos. Soc. **23**: 39; 1924.

points at which the integral curves of (20) have a slope s is given by

$$\frac{dN_1}{dN_2} = \frac{f_1}{f_2} = s \tag{21}$$

or

$$f_1 - s f_2 = 0 \tag{22}$$

This defines the *isoclines* as a family of conics, which in point of fact are, in the present case, hyperbolas. The construction has been carried out with the results shown in Figure 2, which exhibits a number of

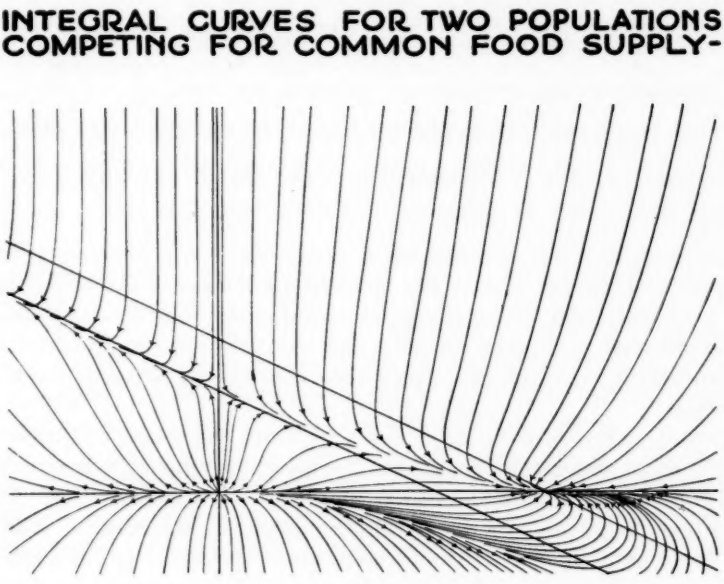


Figure 3.

properties of the isoclines. By their aid a map of the family of integral curves has been drawn which is reproduced here in Figure 3. A part of the negative field has been included merely for its geometrical interest; it has, of course, no concrete meaning for our present problem.

The following characteristics of this map are particularly noteworthy:

At the origin of N_1, N_2 there is an unstable equilibrium characterized by a stream of integral curves all directed away from the origin (when the time is taken into consideration). This corresponds to the two positive roots of the characteristic equation.

There is a second unstable equilibrium at $N_1 = 1/p_1h$, $N_2 = 0$. Here the integral curves approach, then turn away, *avoiding* the equilibrium point. This corresponds to two roots λ of opposite sign, of the characteristic equation.

The third equilibrium at $N_1 = 0$, $N_2 = 1/p_2k$, is stable, the integral curves streaming in from all sides. This corresponds to the two negative roots λ of the characteristic equation.

The locus of the centers of the isocline hyperbolas is a parabola. In particular, the center of the isocline for slope ∞ lies at the intersection of the parabola with the axis of N_1; the center of the isocline for slope zero lies at the intersection of the parabola with the axis of N_2.

The axes of N_1, N_2 themselves are isoclines, the axis of N_1 corresponding to slope ∞, the axis of N_2 corresponding to slope zero.

The second isocline for slope ∞ is parallel to the second isocline for slope 0, the tangent of their inclination to the horizontal being $-\frac{k}{h}$.

Of the asymptotes of the isocline hyperbolas, one always has the inclination $-\frac{k}{h}$ to the horizontal. The inclination of the other is proportional to the slope s characteristic of the isocline to which it belongs.

Let us now briefly consider the implications of Volterra's restriction that $h_1 = h_2$, and $k_1 = k_2$. The physical significance of this restriction is, essentially, that the two species consume one and the same single food material, or, if they consume a mixed diet, that the proportion of each ingredient of the diet which they consume is the same for both species.

Now this is a rather narrow and unrealistic restriction. Moreover, if we adopt the general method of treating the subject, it is unnecessary. The solution applies just as well if $h_1 \neq h_2$ and $k_1 \neq k_2$. Certain significant differences, however, appear in the result. Instead of three equilibria in the finite field, there are now four, and one of these may be such that not only one species survives, but both. This is more in keeping with the facts of nature, since it is a matter of the most common knowledge that a great variety of species of organisms sharing certain sources of food do live together in essentially stable equilibrium.

It is well known that the Verhulst-Pearl curve of population growth for a single species has been found to fit very acceptably a number of observed cases, among them the growth of the human population of the United States, and also certain laboratory populations of fruit flies and other organisms.

It is perhaps hardly to be expected that concrete examples of the law of growth for two populations here discussed shall be found in nature. There is better prospect of realizing it in a laboratory popula-

tion, though the difficulties of establishing the requisite conditions will here be considerably greater than in the case of a single population. It would be interesting to see the experiment actually made.

But it is possible that the treatment which has here been developed in the analysis of the growth of multiple populations, may find more immediate application in the field of economics. For our variables N_1 and N_2 may be conceived as denoting the size or extent of two (or more) commercial enterprises competing for common sources of supply and for a common market. It will be recalled that Cournot's treatment of the problem of competition has been criticized on the ground that under the conditions of the problem, as analyzed by him, any one competitor who should possess the slightest advantage over the others, would ultimately displace them entirely, and hold the field in absolute monopoly. This criticism, however, is justified only on the assumption that the sources of supply and the markets are equally accessible, in their entirety, to all the competitors. In actual fact, with competitors scattered over an area, each has a certain surrounding territory in which he has an advantage over his competitors. In these circumstances the criticism levelled at Cournot falls to the ground.[8] These observations are strongly reminiscent of the facts we observed in the analysis of competition among growing populations, regarding the effect of varying in *some* degree at least the composition of the diet of the competing populations. In the same way two competing commercial firms, though they may sell to the same set of people, will not sell to their several local zones in identical proportions. That an application of an analysis similar to that here set forth should present itself as a possibility in dealing with economic systems is only natural, since economic competition is, after all, only a special form of the more general phenomenon of biological competition.

[8] Compare H. HOTELLING, Economic Journal (London) **41**: 41; 1929.

GEOLOGY.—*Faults and joints in the Coastal Plain of Maryland.*[1] A. L. DRYDEN, JR., Bryn Mawr College. (Communicated by W. H. BRADLEY.)

In the various papers on the Coastal Plain formations of the Middle Atlantic States one finds but few references to faulting. McGee[2] thought the rapid change of topography near the fall-line was the result of monoclinal folding or faulting. Clark[3] sought to explain

[1] Received July 11, 1932. Published by permission of the State Geologist of Maryland.

[2] W J McGEE. U. S. Geol. Survey Seventh Ann. Rept. pp. 616–634. 1888.

[3] W. B. CLARK, A. B. BIBBINS, and E. W. BERRY. Maryland Geol. Survey, Lower Cretaceous, pp. 61, 85, 86. 1911.

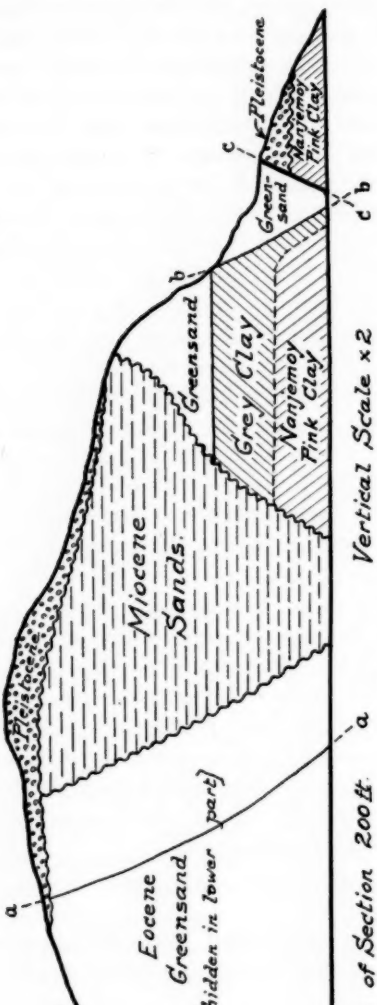

Pleistocene
Nanjemoy Pink Clay
Green-sand
c
b
Miocene Sands
Greensand
Grey Clay
Nanjemoy Pink Clay
Eocene Greensand (hidden in lower part)
a
Length of Section 200 ft.
Vertical Scale ×2

Fig. 1A.

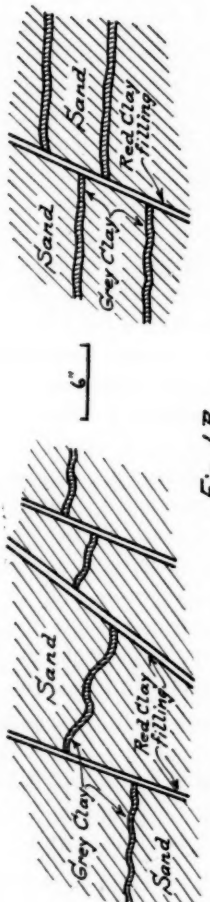

Sand
Sand
Red Clay filling
Grey Clay
6"
Sand
Grey Clay
Red Clay filling
Sand

Fig. 1B.

certain "abnormal" altitudes of lower Cretaceous strata by faulting. No direct proof of this faulting was given. Two reports of faulting in the Coastal Plain of New Jersey, with photographs of fault traces, are the only acceptable accounts which have come to the writer's attention.[4,5]

Faulting in the Coastal Plain of Maryland may easily be overlooked. First, there are, as yet, no difficulties in correlation which could be explained by faults of large throw. Faults, then, probably are either small or absent. Second, faults would have no topographic expression, nor would their fault planes be distinguishable in the homogeneous, unconsolidated sands and clays. Clay lenses or indurated layers are not ordinarily present, but generally where such datum planes are found, faults are plainly absent. At one exposure, however, an indubitable fault has been observed, and at two other localities movement along joints or cracks is clearly shown.

At a curve on the Crain Highway 3.3 miles south of the southern railroad crossing at Upper Marlboro, Prince George's County, there is exposed a section of Eocene, Miocene, and Pleistocene beds. Figure 1A[6] illustrates the relations found here. There are at least two lines, lettered *a-a* and *b-b*, in this section which may represent faults, or which may be erosional features, though such erosional irregularities have not been noted elsewhere within the Eocene deposits. The line marked *c-c*, however, undoubtedly represents a fault, along which the Pleistocene beds are brought sharply against Eocene material. The direction of dip of the fault plane precludes the possibility that slumping has given rise to this relationship. The throw on this fault, however, cannot be more than 15 feet (as is indicated by the thickness of the Nanjemoy clay) and may be as little as 1 or 2 feet. The Pleistocene remnant to the right of the fault has been preserved by downfaulting, as there is none just to the left of the fault.

In a road cut on the steep hill $\frac{3}{4}$ mile east of Newtown, Newtown-Dentsville road, Charles County, clayey sands of the lower Calvert formation are exposed. Where the cut had been recently "dressed" by road employees the relations shown in figure 1B were observed. The "joints" are indicated by bands of red clay about half an inch in thickness which was apparently derived from the overlying Pleistocene deposits. In a road cut about 100 yards west of Well's Corner, near

[4] H. Ries, H. B. Kummel, and G. N. Knapp. New Jersey Geol. Survey. **6**: 16. 1904.

[5] R. D. Salisbury and G. N. Knapp. New Jersey Geol. Survey. **8**: 79. 1917.

[6] Miss I. M. Hellmer of Bryn Mawr College has kindly drawn the accompanying figures.

Upper Marlboro, Prince George's County, the same features are shown, except that the clay bands are very thin. Such clay bands, resembling joints or cracks, have been observed in the same beds at numerous other localities. Their true nature is problematical. Monroe[7] has described "cracks" which may be similar to the "joints" observed here. The joint lines in this area have a polygonal pattern when seen as traces on a horizontal surface. The polygons bounded by these structural lines have from three to five or more sides, and may be 1 to 6 feet in greatest diameter. The joint lines do not cross. Moreover, they were found only in sand beds which, however, contain so much admixed clay that a coherent ball can be formed from the moist material. These structural lines have been traced for about 15 feet vertically. They die out below, and are usually truncated by erosion surfaces above. They may, of course represent cracks due to shrinkage resulting from desiccation, but, for want of conclusive information, their origin remains in doubt.

The foregoing description of small faults and joints seems to have an interesting relation to the structural history of the region.

It is believed (on evidence to be presented later) that the lower Calvert and underlying beds in southern Maryland have been differentially warped. The joints and small faults are possibly related to this movement. The upper Calvert (Plum Point Marls) has been tilted without differential warping and in its exposure for 15 miles along the Calvert Cliffs, Calvert County, no small faults nor any of the joints of the type so common in the lower Calvert were observed.

The faults shown in figure 1A are of Pleistocene or Recent age. The movement along the joints of the lower Calvert, as illustrated in figure 1B, may be of Pleistocene age, but at that locality the Pleistocene overlies the Calvert with a sharp, straight-line contact which shows no sign of disturbance. From the evidence available, therefore, it seems more probable that the warping and jointing occurred at the end of lower Calvert time, although the fact that the upper Calvert (Plum Point Marls) is restricted to eastern Calvert County and does not extend into the area discussed leaves the upper limit of such dating open to doubt.

[7] W. H. MONROE. Amer. Assoc. Petrol. Geol. Bull. **16**: 214. 1932.

PALEONTOLOGY —Holopea symmetrica *Hall, genotype of* Holopea *Hall.*[1] J. BROOKES KNIGHT, Yale University. (Communicated by JOHN B. REESIDE, JR.)

In the course of some work on Paleozoic gastropods I have had occasion to run to earth that frequently cited, but imperfectly known, genus *Holopea* Hall. *Holopea* is imperfectly known in two senses; that the knowledge we have of it is not derived from studies of the genotype, so inadequately described and poorly figured by Hall; and that the limits of the genus are so broadly defined as to include much that does not belong to it. I have little to offer to mitigate the latter difficulty except as I am able to clear up the first. The foundations of our knowledge of a genus must be based on the genotype, and it is with the genotype of *Holopea* that this paper will deal. This study will fortunately not alter materially the concept of the genus employed by modern systematists such as Ulrich, Koken, Cossman or Perner, but it is to be hoped that it will give a foundation for that concept that has hitherto been lacking.

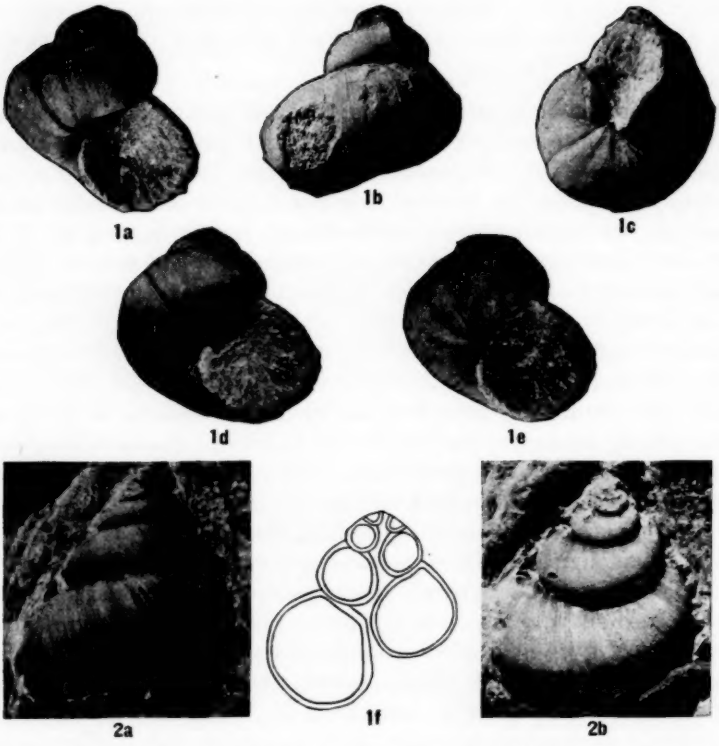
The genus *Holopea* was described by Hall as early as 1847 (1, p. 169) and among the species described at that time was *H. symmetrica* Hall. Hall did not designate a genotype nor seemingly did any of the several authors who discussed the genus before 1889. In 1889, however, S. A. Miller named *H. symmetrica* Hall and *H. obliqua* Hall as genosyntypes (2, p. 405) thus narrowing the field for selection, and Bassler in 1915 (3, p. 625) designated *H. symmetrica* genoholotype. Cossman's designation in 1915 (4, p. 19) of *H. paludiniformis* Hall is, of course, invalid.

The holotype of *H. symmetrica* is deposited in the Hall collection at the American Museum of Natural History, New York, their catalogue No. 751, and Dr. Chester A. Reeds of that museum has been good enough to lend me the specimen for study. Contrary to the condition of most specimens of *Holopea* it is excellently preserved, although most of its base and all of the aperture are buried in matrix. This specimen is shown as Figures 2*a-b* of this paper.

The holotype serves to show very clearly the general form and the surface characters of the species though, except by means of preparation that one does not like to undertake on the sole type specimen of the species, the critical apertural and umbilical characters may not be learned from it.

Searching for other specimens which might show the aperture, I

[1] Received August 9, 1932.



Figures 1 *a-f*. *Holopea symmetrica* Hall. The T. G. White plesiotype mentioned in the text. *a-e*. Various views to show form, ornamentation and apertural characters. *f*. Diagrammatic, *camera-lucida* sketch of polished section. Owing to the re-crystallization of the shell-wall, it was difficult to place accurately the boundaries between shell and matrix, except in the last half whorl (lower left) where they are placed with some accuracy. The inner shell boundaries of the other whorls are approximations. The orientation of the section is very slightly oblique and the umbilicus in the last whorl therefore appears a little narrower than if the plane of the section had passed through its center. Yale Peabody Museum No. 13,833.

Figures 2 *a-b*. *Holopea symmetrica* Hall. The holotype. Two views to show form and ornamentation. This specimen is the original of Hall's illustration, figure 1, plate 37, volume 1, Palaeontology of New York. Amer. Mus. of Natural History, James Hall Collection, Catalogue No. 751.

All figures × 3. Photographs not retouched

came across T. G. White's observations on some specimens of unusually good preservation from the Trenton limestone near Trenton Falls, N. Y. (5, p. 85). The preservation of these specimens is excellent and identical in character to that of Hall's holotype, but they do not, as

claimed by White, retain any shell material in its original form nor any trace of pearly lustre. The shells retain the minutest details of surface ornamentation but are wholly and rather coarsely recrystallized internally. They do show a sheen, which White seems to have mistaken for pearly lustre, but this is caused by the contrast of the translucent, recrystallized shell material with the very dark, finely crystalline limestone of the matrix. The coarsely crystalline texture of the shells can be seen in fractures and, even better, in polished sections. Dr. G. Marshall Kay of Columbia University very kindly loaned me all of White's specimens for study and, indeed, presented me with one of them. These specimens were compared carefully with the holotype and one of them was removed from the matrix and cleaned with a needle to expose the base and the aperture. This specimen was photographed, then casts were made to preserve a record of its form and finally an axial section was cut. The photographs and a drawing from the section are reproduced as Figures 1*a-f* of this paper.

On the basis of studies of the holotype and the T. G. White specimens, the species is redescribed in the following terms:—

Holopea symmetrica Hall

Holopea symmetrica Hall, 1847, Palaeontology of New York **1**: 170; pl. 37, fig. 1. Upper, crystalline portions of the Trenton limestone at Middleville, New York. White, 1895, Trans. N. Y. Acad. Sci. **15**: 85, Trenton limestone, Trenton Falls, New York. Weller, 1903, Geol. Surv. New Jersey; Paleont. **3**: 186, pl. 12, figs. 26, 27, Trenton limestone, Jacksonburg, New Jersey.

DIMENSIONS OF *A*, THE HOLOTYPE (FIGS. 2 *a-b*) AND *B*, A T. G. WHITE PLESIOTYPE (FIGS. 1 *a-f*)

	A	*B*
Number of whorls	6[a]	6[b]
Height	11.5 mm[a]	11.0 mm[b]
Width	11.25 mm	11.0 mm
Ratio of height to width	1.02	1.00
Ratio of height of body whorl to total	0.79	0.84
Pleural angle	61°	70°

a. Estimated on the assumption that 2 apical whorls are missing.
b. Estimated on the assumption that 3 apical whorls are missing.

Moderately small, turbinate gastropods with straight sides, evenly and roundly convex whorl profile and deep sutures; the roundness of the whorl profile continuing uninterruptedly across the base and into the umbilicus; aperture sub-circular; apertural margin only in contact with the previous whorl for a short distance, the ends of the free margins being connected by a thin, parietal inductura; outer lip oblique in side view and only very slightly sinuous; inner lip thin, nearly vertical and slightly reflexed; columella narrowly phaneromphalous; ornamentation, very fine growth lines superimposed on irregular and indistinct transverse undulations. The nucleus has not been observed.

It is curious to note that Hall, in his original description, states that the height is much greater than the breadth whereas both the holotype and even Hall's very poor original figure show the height to be only very slightly greater than the breadth. Obviously his statement was founded on a cursory inspection and not on measurements. The apparent relative height of a gastropod shell is very deceptive.

It is unfortunate indeed that the shell structure of none of the specimens is preserved, for if it were it seems very probable that it would show an internal nacreous layer and confirm the conclusion arrived at on other grounds, that the genus should be placed with the Trocho-turbinidae of Koken, an admittedly composite group of family rank used for fossil Trochids and Turbinids which cannot be further distinguished in the light of present knowledge. I would, for the present, include in the Trocho-turbinidae, the Trochonematidae Zittel in which family *Holopea* is placed by Koken and Perner (6, p. 213), by Cossman (4, p. 19) and by Ulrich (7, p. 1064). There appears to be no justification for placing *Holopea* in the Littorinidae as is done by Perner (8, p. 313) and in Zittel's Textbook.

In addition to those curators of collections whose kindness in lending me specimens has been acknowledged in the text, I am indebted to Dr. Ray S. Bassler of the United States National Museum for checking certain references not available to me.

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BOTANY.—*Mosses of Northern Guatemala and British Honduras.*[1]

EDWIN B. BARTRAM, Bushkill, Pa.

The mosses listed below were collected by Professor H. H. Bartlett during the early months of 1931 in the El Cayo region of western

[1] Received July 8, 1932. This paper is based (in part) upon collections made in a biological survey of the Maya area conducted by the University of Michigan in collaboration with the Carnegie Institution of Washington.

British Honduras and in the Petén district of Guatemala.[2] The list is an especially interesting one as it is the first record of the mosses from an area that has been a bryological blank on the map of Central America. In a general way the species show a close and very natural relation to those known from the State of Vera Cruz and the Yucatan peninsula but there are also suggestive connections with well known species from the Antilles and northern South America that tend to emphasize the interlocking distribution of the mosses of all the regions bordering the Caribbean Sea.

In the following list the numbers followed by the symbol *B.H.* are from the Mountain Pine Ridge in the vicinity of El Cayo, British Honduras while the collections from the limestone areas in the vicinity of Uaxactun, Petén district, Guatemala, are followed by the symbol *P.*

FISSIDENTACEAE

FISSIDENS RETICULOSUS Schp. 12553 *P.* in part

FISSIDENS LEPTOPODUS Card. 12155 *P.*; 12545 *P.*; 12553 *P.*, in part; 12643 *P.*

While these collections deviate in several minor particulars from the type collection of *F. leptopodus* Card. the differences do not seem to be important enough to warrant the creation of a new species. The Guatemalan plants are generally more freely branched with up to 25 or 30 pairs of leaves; the leaves are less crispate, rather more bluntly pointed and the border of the duplicate blades, in the upper leaves, narrower and less distinct but these characters are all subject to some variation within reasonable limits. Evidently the species should be placed in the Section *Semilimbidium* rather than in *Crenularia*.

FISSIDENS GARBERI Sull. & Lesq. 12485 *P.*

DICRANACEAE

Campylopus (Palinocraspis) Bartletti sp. nov.

Sterilis. Caespites densi. Caulis ad 7 cm. longus, simplex vel parce ramosus, dense tomentosus. Folia 6 mm. longa, sicca erecto-appressa, humida patula, oblongo-lanceolata, concava, in pilum hyalinum denticulatum producta; marginibus planis, superne serrata; costa basi 375μ, dorso sulcata, superne serrulata, breviter excurrente; auriculis distinctis; cellulis suprabasilaribus quadratis ad 25μ latis, marginalibus haud linearibus, cellulis laminae ovalis vel rhomboidalibus.

Robust plants in dense tufts or mats, bright yellowish green, slightly glossy. Stems procumbent, up to 7 cm. long, flexuose, simple or dichotomously branched above, densely reddish tomentose throughout. Leaves uniformly spaced, erect when dry, widely spreading when moist, about 6 mm. long, deeply concave, oblong-lanceolate, gradually narrowed to a slender

[2] *Cf.* HARLEY HARRIS BARTLETT. *A biological survey of the Maya area.* Bull. Torrey Bot. Club **59**: 7–20. 1932.

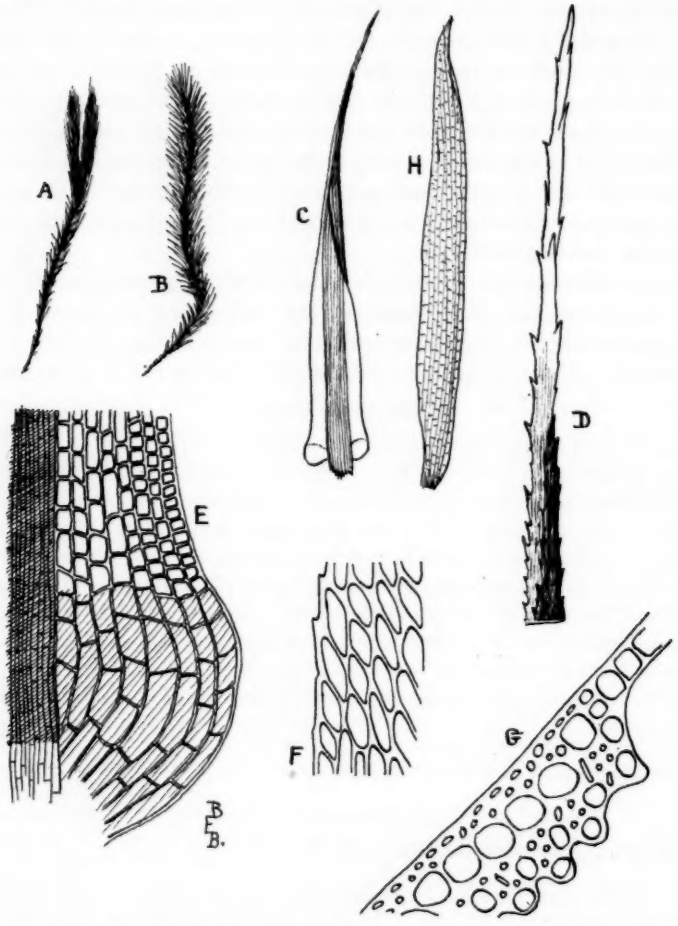

Figure 1.—*A-G.* **Campylopus Bartlettii** Bartr. sp. nov.—*A*—dry plant × 1.—*B*—moist plant × 1.—*C*—leaf × 14.—*D*—apex of leaf × 80.—*E*—one side of leaf base × 160.—*F*—upper leaf cells and margin × 440.—*G*—part of cross-section of costa × 440.
H. Leucobryum albidum forma subulifolium, modified leaf × 80.

point; margin erect, coarsely serrate near the apex, entire below; costa about 375μ wide below, occupying more than half of the leaf base, excurrent in a hyaline, denticulate point about 1 mm. long in the upper leaves, ribbed on the back and slightly serrulate near the apex, in cross-section showing a median row of large cells with a narrow stereid band on the ventral side and a wider band on the dorsal side; alar cells conspicuous, extending to the costa, usually with reddish walls, cells of the leaf base, just above the alar group, quadrate or short rectangular, up to 25μ wide, smaller but not elongate

toward the margins, gradually becoming smaller and oval-rhomboidal upward, upper cells oval-rhomboidal, 6–7μ wide by 2–3 times as long, distinct to the base of the hyaline point. Inflorescense and fruit unknown.

Type: Pine Ridge, Duck Run, El Cayo District, British Honduras, H. H. Bartlett no. 12973, April 24, 1931.

A very handsome and unique species that naturally suggests a comparison with *Campylopus Richardi* Brid. on account of the costal structure and hyaline leaf tips. In *C. Bartletti* the color, habit, and particularly the large quadrate basal cells not at all narrowed toward the margins and the shorter cells of the upper leaf blade are strikingly distinct and it is very evident that the two species have little in common. The basal areolation of *C. savannarum* (C.M.) Mitt. is quite similar but the leaves of this species lack the conspicuous hyaline tips.

It is a privilege to be able to associate Prof. Bartlett's name with such an unusual plant from an area that, heretofore, has been practically unknown bryologically.

HOLOMITRIUM CALYCINUM (Hedw.) Mitt. 11691 *B.H.*

LEUCOLOMA CRUGERIANUM (C.M.) Jaeg. 11708 *B.H.*; 11721 *B.H.*; 11735 *B.H.*

LEUCOBRYACEAE

OCTOBLEPHARUM ALBIDUM Hedw. 11228 *B.H.*; 11692 *B.H.*; 12297 *P.*

OCTOBLEPHARUM CYLINDRICUM Schp. c. fr. 12972 *B.H.*

Mr. Williams credits this species to Jamaica[3] on the basis of a single, rather dubious specimen. The collection from British Honduras is in perfect fruiting condition and confirms the occurrence of the species in North America without any question.

OCTOBLEPHARUM PULVINATUM (D. &. M.) Mitt. 12030 *B.H.*; 12610 *P.*

OCTOBLEPHARUM MITTENII Jaeg. 11641 *B.H.*

In addition to the differences previously mentioned[4] this species will be distinguished from *O. erectifolium* Mitt. by the lamina cells of the leaf base in two layers. The upper part of the leaf, when viewed from either surface, shows a distinct median line, 2–4 cells wide, due to the thickening of the leaf in this area.

LEUCOBRYUM ALBIDUM (Brid.) Lindb. 11634 *B.H.*

LEUCOBRYUM ALBIDUM (Brid.) Lindb. forma subulifolium. 11690 *B.H.*; 12729 *P.* Folia superiora subulata congesta.

These two collections represent a peculiar form with the upper leaves subulate and densely crowded. Collections from Mexico and Costa Rica show plants with a similar tendency but not nearly so conspicuous as in 11690

[3] N. A. Flora **15**, part 2: 161. 1913.

[4] Contrib. U. S. Nat. Herb. **26**, part 3: 72. 1928.

where the modified upper leaves, which probably serve the purpose of vegetative reproduction, are abundant enough to give the tufts a peculiar silky appearance entirely foreign to the typical plants. The plants bearing these apical clusters of modified leaves are in no way different from the normal plants with which they are associated and evidently represent only a minor variant.

CALYMPERACEAE

SYRRHOPODON INCOMPLETUS Schwaegr. 12031 *B.H.*; 12085 *B.H.*; 12250 *P.*; 12488 *P.*

CALYMPERES LONCHOPHYLLUM Schwaegr. 11738 *B.H.*; 12441 *P.*; 12472 *P.*; 12636 *P.*

As far as I know this species has never been actually recorded from Central America. Prof. Bartlett's collections are ample and generally well fruited so that it would appear that the species is not at all uncommon in this area. The plants in the above collections show the leaves uniformly without teniolae and rather shorter than average plants from the Antilles and Venezuela but the consistently short stems, less than 5 mm., indicate that they should be referred here rather than to *C. Levyanum* Besch.

POTTIACEAE

BARBULA CRUGERI Sond. 12543 *P.*

DESMATODON GARBERI Lesq. & James. 12541 *P.*

FUNARIACEAE

FUNARIA CALVESCENS Schwaegr. 11851 *B.H.*

BRYACEAE

BRYUM ANDICOLA Hook. 11898*a* *B.H.*

RHODOBRYUM BEYRICHIANUM (Hsch.) Par. 12604 *P.*; 12636 *P.*

ORTHOTRICHACEAE

MACROMITRIUM MUCRONIFOLIUM (Hook. & Grev.) Schwaegr. 12315 *P.*

MACROMITRIUM PENTASTICHUM C.M. 11692*a* *B.H.*; 11693 *B.H.*

MACROMITRIUM CIRRHOSUM (Hedw.) Brid. 11734 *B.H.*

SCHLOTHEIMIA MOHRIANA C.M. 13047 *B.H.*

HELICOPHYLLACEAE

HELICOPHYLLUM TORQUATUM (Hook.) Brid. 13136 *B.H.*

RHACOPILACEAE

RHACOPILUM TOMENTOSUM (Hedw.) Brid. 12251 *P.*; 12516 *P.*; 12646 *P.*; 12714 *P.*; 12716 *P.*; 12730 *P.*; 12749 *P.*

LEUCODONTACEAE

LEUCODONTOPSIS FLORIDANA (Aust.) E. G. Britt. 12044 *B.H.*; 13094 *B.H.*
PSEUDOCRYPHAEA FLAGELLIFERA (Brid.) E. G. Britt. 12493*c P.*

PTEROBRYACEAE

ORTHOSTICHOPSIS TETRAGONA (Hedw.) Broth. 11736 *B.H.*; 12324 *P.*; 12442 *P.*

PIREELLA CYMBIFOLIA (Sull.) Card. 12472*a P.*; 12493*a P.*

No. 12493*a* shows the following sporophyte characters: seta reddish, erect, flexuose, 8–10 mm. long, smooth; capsule erect, ovoid-cylindric, brown, 2–2.25 mm. long by 0.5 mm. wide, slightly narrowed at the mouth; spores brownish, papillose, 22–25μ in diameter; peristome, lid and calyptra not seen (capsules all old and deoperculate).

PIREELLA PACHYCLADA (Ren. & Card.) Card. 12265 *P.*; 12486 *P.*

These collections seem to agree perfectly with the description of the type collection from Yucatan. The following sporophyte characters are taken from several fruiting plants found in no. 12486: seta erect, reddish, flexuose, smooth, 4–5 mm. long; capsule erect, oblong-cylindric, up to 2.5 mm. long by 0.35 mm. wide, brownish, slightly narrowed above (capsules old and deoperculate).

Upon comparing this species with *P. Mariae* (Card.), of Costa Rica, it will be noticed that, in addition to the differences in vegetative characters, the size and shape of the respective capsules are thoroughly distinctive and that the setae of *P. pachyclada* are smooth throughout.

METEORIACEAE

PAPILLARIA NIGRESCENS (Hedw.) Jaeg. 12482 *P.*; 12498 *P.*, in part ; 13046 *B.H.*; 13047*a B.H.*

METEORIOPSIS PATULA (Hedw.) Broth. 12484 *P.*; 12670 *P.*; 12671 *P.*; 12728 *P.*

NECKERACEAE

NECKEROPSIS UNDULATA (Palis.) Broth. 12265*a P.*; 12493*b P.*
NECKEROPSIS DISTICHA (Hedw.) Fleisch. 12452 *P.*; 13146 *B.H.*

HOOKERIACEAE

CALLICOSTELLA PALLIDA (Hsch.) Jaeg. 11845 *B.H.* in part; 12597 *P.* in part; 12598 *P.*; 12616 *P.* in part.

FABRONIACEAE

HELICODONTIUM TENUIROSTRE Schwaegr. 13135 *B.H.*

THUIDIACEAE

HAPLOCLADIUM MICROPHYLLUM (Hedw.) Broth. 12616 *P.*
THUIDIUM INVOLVENS (Hedw.) Mitt. 12251 *P.*; 12255 *P.*; 12259 *P.*; 12260 *P.*; 12480 *P.* in part; 12498 *P.* in part; 12597 *P.*

SEMATOPHYLLACEAE

RHAPHIDORRHYNCHIUM SUBSIMPLEX (Hedw.) Broth. 11739 *B.H.*
SEMATOPHYLLUM CAESPITOSUM (Hedw.) Mitt. 13150 *P.*
SEMATOPHYLLUM LOXENSE (Hook.) Mitt. 11845 *B.H.*; 11846 *B.H.*; 11847 *B.H.*
TAXITHELIUM PLANUM (Brid.) Mitt. 11739 *B.H.* in part; 12252 *P.* in part; 12272 *P.* in part; 12490 *P.* in part; 12452 *P.* in part; 12516 *P.* in part; 12597 *P.* in part; 12598 *P.* in part; 12616 *P.* in part; 12729 *P.* in part.

HYPNACEAE

VESICULARIA AMPHIBOLA (Spr.) Broth. 12597 *P.* in part.
MICROTHAMNIUM THELISTEGUM (C.M.) Mitt. 11720 *B.H.*; 12252 P.; 12255 *P.* in part; 12258 *P.*; 12259 *P.* in part; 12272 *P.*; 12314 *P.*; 12480 *P.*; 12498 *P.*; 12499 *P.*; 12517 *P.*; 12539 *P.*; 12713 *P.*, 12716*a* *P.*

ZOOLOGY.—*The male of the nematode species,* Neotylenchus abulbosus, *Steiner, and its sexual dimorphism.*[1] G. STEINER and EDNA M. BUHRER, Bureau of Plant Industry.

The male of the species *Neotylenchus abulbosus* Steiner[2] was not known until recently, when a single specimen was found among numerous larvae and females parasitizing a diseased carrot grown in Sweden and intercepted at the port of Philadelphia by the Plant Quarantine and Control Administration inspectors. The shape and general structure of this single specimen seem to exclude any other relationship than that with the aforementioned species.

This male is slightly smaller and more slender than the average females. The annulation of the cuticle is extremely faint; only on the bursa is it more evident (Fig. 1, B). In general, this male somewhat resembles that of *Tylenchus dipsaci*, just as there is also a resemblance between the mutual females. The front of the head end shows the 8 sectors typical of the female; likewise, the esophagus has no bulb. The most interesting feature, however, is the almost completely vanished spear. As depicted in fig. 1, A only the rodlike cuticularized

[1] Received July 19, 1932.

[2] STEINER, G. Neotylenchus abulbosus, *n.g., n.sp.* (*Tylenchidae, Nematoda*) *the causal agent of a new nematosis of various crop plants.* This JOURNAL **21**: 536–538. 1931.

supports of the lip region remain of the whole apparatus as found in the female and the larva. The shaft of the spear, the conical point, and also the basal knobs have faded; the posterior end is faintly marked by the dim outlines of protrudor muscles.

This case seems to be analogous to that of *Tylenchus similis* where the male also differs from the female and larva in the remarkable reduction of the spear. Perhaps this obliteration indicates that these males cease to feed in the adult stage either because they are not functional (in the case of *Neotylenchus abulbosus* (?)) or because they copulate but once during their life (perhaps in *Tylenchus similis*). Both forms are evidently endoparasites of plants. Two remarkable larvae of *N. abulbosus*, perhaps males of the preadult stage, were recently found in strawberry plants from California which were affected with "yellows" or "xanthosis" and which often harbor this nema. Their spear had vanished as in the male specimen here described, indicating an early loss or even a complete absence of the spear also in the larval stages of the male.

As to the copulatory apparatus, the present male displays a well developed bursa, reaching from in front of the spicula to the tail end, which is pointed and set off (Fig. 1, B). No bursal rays or ribs were seen. The spicula are remarkably small but very similar in form to those of *T. dipsaci*. An extremely small lineate gubernaculum was also seen.

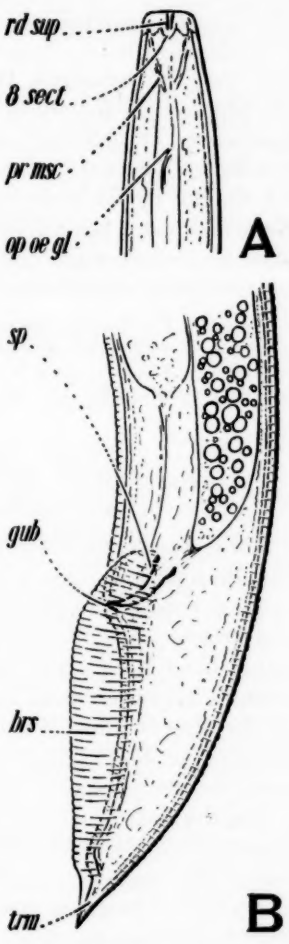

Fig. 1.—*Neotylenchus abulbosus*, male. A.—Head end; *rd sup*, rodlike supports; *8 sect*, 8 sectors of the head; *pr msc*, protrudor muscles of the spear; *op oe gl*, opening of esophageal gland. B.—Tail end; *sp*, spicula; *gub*, gubernaculum; *brs*, bursa; *trm*, setoff portion of tail. × about 1070.

$$\text{Measurements:}\ \frac{-\quad (?)\quad 8.9\quad M\quad 94.9}{-\quad (?)\quad 2.0\quad 2.6\quad 2.0}\ 0.74\ \text{mm.}$$

It may be remarked that *Neotylenchus abulbosus* shows a close resemblance to *Hexatylus viviparus* of Goodey 1926.[3,4] By correspondence, Dr. Goodey called attention to this similarity, thereby causing a detailed re-examination of our material and indirectly the finding of the male specimen. If, as stated in its description, *Hexatylus* has a head divided into only 6 sectors and a spear with 6 basal knobs instead of only 3, then *Neotylenchus abulbosus* and *Hexatylus viviparus* are different. The male of *Hexatylus* is not known.

[3] GOODEY, T. Hexatylus viviparus *gen. et sp. nov., a nematode found in a diseased potato tuber.* Jour. Helminthol. **4**: 27–30. 1926.

[4] GOODEY, T. *A further note on* Hexatylus viviparus *Goodey, 1926.* Jour. Helminthol. **4**: 183–184. 1926.

ZOOLOGY.—*Two new cacomistles from Mexico, with remarks on the genus* Jentinkia.[1] E. W. NELSON, Smithsonian Institution, and E. A. GOLDMAN, Biological Survey.

The generic name *Jentinkia*, proposed by Trouessart (Catal. Mamm., Viv. Foss [suppl.], 1904, p. 184) has not been generally accepted for the tropical cacomistles typified by the animal currently recognized as *Bassariscus sumichrasti* Saussure. Some of the characters of the genus have been mentioned by various authors, and the external features have been dealt with at some length by Pocock, in a discussion of the Procyonidae (Proc. Zool. Soc. London, 1921, pp. 389–422). He says (p. 392): "This Cacomistle is sometimes admitted as a subgenus of *Bassariscus*. I have provisionally quoted it as a distinct genus, the material available being insufficient to establish the absolute constancy of the differences in the feet observable between [*Bassariscus*] *astutus* and *sumichrasti*."

A study of fourteen skins and skulls of *sumichrasti*, of ages varying from very young to quite old, and over one hundred similar specimens of *Bassariscus astutus* leads us to agree with Pocock that *Jentinkia* should be accorded full generic rank.

Jentinkia compares with *Bassariscus* as follows:

Jentinkia	*Bassariscus*
Muzzle and feet distinctly blackish; tail with light rings becoming obsolescent toward end.	Muzzle and feet grayish; tail with light rings distinct throughout its length.
Pelage finer, softer, and more lax.	Pelage coarser and stiffer.

[1] Received August 22, 1932, revised September 9, 1932.

Ears more broadly and evenly rounded.	Ears more narrowly rounded, the margins somewhat produced antero-externally.
Second, third, fourth, and fifth digits of fore and hind limbs naked on lower surface behind digital pads, which are narrower, more elongated.	Second, third, fourth, and fifth digits of fore and hind limbs densely hairy on lower surface behind and around digital pads, which are broader, more rounded.
Claws longer, more strongly curved, more compressed, non-retractile.	Claws shorter, straighter, less compressed, retractile.
Maxillary portion of zygoma placed farther back, the posterior border in plane of second upper molars, or point of contact between these and first upper molars.	Maxillary portion of zygoma placed farther forward, the posterior border in plane of first upper molars.
Foramen ovale opening more directly forward.	Foramen ovale opening more directly downward.
Cusps in large molariform teeth less trenchant, more rounded, with lower, less prominent connecting ridges.	Cusps in larger molariform teeth more trenchant, with higher, sharper connecting ridges.
Upper carnassial triangular in outline, without a postero-internal cusp.	Upper carnassial irregular in outline, with a prominent postero-internal cusp.
Posterior lobe of upper carnassial and anterior lobe of lower carnassial more weakly developed.	Posterior lobe of upper carnassial and anterior lobe of lower carnassial more strongly developed.
Cutting edges of first and second upper incisors, of permanent series, distinctly trifid.	Cutting edges of first and second upper incisors, of permanent series, normally smooth.

Jentinkia inhabits the great forests of tropical Middle America, its range meeting that of *Bassariscus* along the eastern slopes of the Mexican highlands. It is much more arboreal in habits than the latter, which is at home along cliffs and rocky ledges and spends much time upon the ground. The sharp, curved, non-retractile claws of *Jentinkia*, adapted for clinging, appear to be associated with its arboreal life, while those of *Bassariscus*, with cat-like retractility, are better fitted for progression among rocks.

The genus comprises a single species which is subdivisible into closely allied geographic races as follows:

Jentinkia sumicrhasti sumichrasti (Saussure).... Mirador, Vera Cruz, Mexico.
Jentinkia sumichrasti variabilis (Peters)..... Coban, Guatemala.

Jentinkia sumichrasti campechensis, subsp. nov.Apazote, Campeche, Mexico.
Jentinkia sumichrasti notinus (Thomas).....Boquete, Chiriqui, Panama.

B[assaris] astuta was first described by Lichtenstein (Abhand. Akad. Wissensch. Berlin, 1827, p. 119, 1830) in a discussion of the application of names of Mexican mammals treated by Hernandez (Rerum Medicarum Novae Hispaniae Thesaurus, 1651, tract 1 [appendix]). The name appears to be based primarily upon a specimen collected by Deppe who worked extensively in southeastern Mexico. Reference was also made to the cacomistle of the Mexican Indians, currently recognized as *Bassariscus astutus*, which ranges as a species throughout the plateau region of Mexico and northward into the United States. In 1831 Lichtenstein (Isis, vol. 24, p. 513) again described the animal and assigned it to a "Habitat in Mexico." In response to an inquiry Dr. Hermann Pohle has written us that the specimen mentioned was received from Deppe in 1826 "aus Mexiko (wahrscheinlich Stadt Mexiko)," and mounted with the skull inside still exists as number 1081 in the Berlin Museum. We regard specimens from the vicinity of the Valley of Mexico as typical.

Bassariscus albipes Elliott (Field Columb. Mus., publ. 87, zool. ser., vol. 3, p. 258, Dec. 1903) was described from a single specimen obtained "near Vera Cruz, State of Vera Cruz, Mexico." The label, however, shows that the type was taken at Xico, which is near Jalapa, Vera Cruz, on the eastern slope of the highlands. *B. albipes* is identical with typical *B. astutus*.

Western Mexico is inhabited by a smaller subspecies, here described, together with a new form of *Jentinkia*.

Jentinkia sumichrasti campechensis, subsp. nov.

Campeche Cacomistle

Type.—From Apazote (near Yohaltun), central Campeche, Mexico. No. 108291, ♂ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, January 2, 1901. Original No. 14386; X catalogue number 10240.

Distribution.—Tropical lowland forests of the Yucatan Peninsula, probably ranging into northern Guatemala and British Honduras.

General characters.—Very similar to *Jentinkia sumichrasti sumichrasti* of the mountains of Vera Cruz, but considerably smaller; skull smaller, more delicate in structure. Similar in color to *Jentinkia sumichrasti variabilis* of the mountains of south-central Guatemala, but much smaller.

Color.—Type: Ground color of upper parts in general buffy grayish extensively overlaid with black, the black-tipped hairs most abundant on head, nape, and median line of back; sides of head and face, including muzzle all around blackish, interrupted by dull whitish markings over and under eyes; under parts and inner surfaces of limbs light ochraceous buff; ears externally brownish black to the distinct white margins, thinly clothed internally with whitish hairs; fore and hind feet and toes distinctly blackish; tail with five gray rings on basal half succeeded by three obsolescent gray rings, alternating with black rings, becoming clear black above and below toward tip. In other

specimens eight or nine gray tail rings vary in distinctness, tending to become invisible toward the end which is always black. A very young individual is similar to adults, but the ears are pure white on distal half.

Skull.—Similar to that of *J. s. sumichrasti*, but decidedly smaller, less massive; rostrum more slender; audital bullae relatively smaller; dentition variable but usually lighter. Differing from that of *J. s. variabilis* mainly in much smaller size.

Measurements.—Type: Total length, 905 mm.; tail vertebrae, 500; hind foot, 92. An adult male topotype: 863; 474; 87. Two adult females from La Tuxpeña, Campeche: 891, 880; 459, 455; 82, 77. *Skull* (type): Greatest length, 90; condylobasal length, 84.7; zygomatic breadth, 59.8; breadth of rostrum (over root of canine), 17.6; interorbital breadth, 18.5; upper canine-molariform toothrow (alveoli), 32.8; upper carnassial, crown length (outer side), 6.7, crown width, 5.2.

Remarks.—Jentinkia sumichrasti campechensis is characterized mainly by small size. It is an outlying peninsular form, but is contiguous to and doubtless intergrades with both *J. s. sumichrasti* and *J. s. variabilis*.

Specimens examined.—Total number, 8, as follows:

CAMPECHE: Apazote (type locality), 2; La Tuxpeña, 5.

YUCATAN: Buena Vista Xbac, 1.

Bassariscus astutus consitus, subsp. nov.

Michoacan Cacomistle

Type.—From La Salada, 40 miles south of Uruapan, Michoacan, Mexico. No. 126162, ♀ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, March 16, 1903. Original No. 16151.

Distribution.—Central Michoacan and Jalisco, and northward through the Sierra Madre to southern Sinaloa, passing farther north into *Bassariscus astutus arizonensis*.

General characters.—Closely allied to *Bassariscus astutus astutus*, of the vicinity of the Valley of Mexico, but decidedly smaller; pelage shorter; general color about the same, but toes of hind feet grayish, mixed with dusky (usually white in *astutus*); skull slightly different. Similar in size to *B. a. flavus* of Texas; color much grayer, less ochraceous buff; cranial characters distinctive. Differing from *B. a. arizonensis* of Arizona, in considerably larger size, and well-marked cranial details; color similar.

Color.—Type: Ground color of upper parts in general buffy grayish, the top of head, middle of neck and back overlaid with black, the dark hairs thinning out along sides and over thighs; rump suffused with pale ochraceous buff; face, including sides of muzzle and cheeks blackish, relieved by whitish markings over and under eyes; throat, inner sides of limbs and inguinal region white; under side of neck, chest, and area across abdomen light buffy; ears blackish on basal half externally, becoming silvery grayish toward tips, and thinly clothed with grayish hairs internally; outer sides of forearms mixed buffy grayish and dusky; fore feet buffy grayish; hind feet grayish above, mixed with dusky over metatarsus and toes, the soles blackish posteriorly; tail with eight alternating black and white rings and a black tip.

Skull.—Very much like that of *B. a. astutus*, but distinctly smaller; braincase relatively narrower; rostrum and frontal region high as in *astutus*; dentition about the same. Compared with *B. a. flavus* the skull is of about the

same size but differs in important features as follows: Braincase relatively narrower, more elongated; frontal region higher, less sloping anteriorly; rostrum heavier (broader and deeper). Larger than that of *B. a. arizonensis*, with a higher but relatively narrower frontal region; zygomata more widely spreading; braincase relatively narrower, more elongated, instead of rounded and inflated; rostrum less tapering.

Measurements.—Type: Total length, 755 mm.; tail vertebrae, 380; hind foot, 78. An adult male topotype: 793; 400; 80. *Skull* (type): Greatest length, 82.3; condylobasal length, 78.3; zygomatic breadth, 50.2; breadth of rostrum (over root of canine), 15; interorbital breadth, 16.2; upper canine-molariform tooth row (alveoli), 31; upper carnassial, crown length (outer side), 7.2, crown width, 4.8.

Remarks.—B. a. consitus is more closely related to *B. a. astutus* than to any of the other known forms, although in size it more nearly approaches *B. a. flavus*. The specimens available indicate a range extending down from the mountains into tropical parts of western Mexico, while typical *astutus* occupies the higher plateau region to the east.

Specimens examined.—Total number, 8, as follows:

JALISCO: Ameca, 1; Bolaños, 1; Ocotlan, 2.

MICHOACAN: La Salada (type locality), 3.

SINALOA: Plomosas, 1.

ZOOLOGY.—*A new pocket mouse from Southern Arizona.*[1] E. A. GOLDMAN, Biological Survey.

The descriptions of two new subspecies of *Perognathus amplus* were recently published (this JOURNAL **22**: 386–388). They were based on a study, by the writer, of 68 specimens referable to the species, from 20 localities in Arizona. While the paper was in press 23 additional examples were received, unexpectedly, from the Tucson region, in the southeastern part of the State. These present differential characters that seem to warrant the recognition of still another new geographic race. The material now available proves that *P. amplus*, known originally from a single individual only, ranges throughout most parts of the Lower Sonoran Zone in Arizona; but the species has not yet been recorded beyond the borders of the State.

Perognathus amplus taylori, subsp. nov.

Pima Pocket Mouse

Type.—From Santa Rita Range Reserve (near Northeast Station), 35 miles south of Tucson, Pima County, Arizona (altitude about 4,000 feet). No. 250533, ♀ adult, U. S. National Museum (Biological Survey collection), collected by Walter P. Taylor, August 3, 1930. Original No. 1899.

Distribution.—Desert region of southern Arizona and probably northern Sonora, east of the range of *Perognathus amplus rotundus*.

[1] Received August 22, 1932.

General characters.—A small, richly colored subspecies, with a delicately formed skull. Closely allied to *Perognathus amplus amplus* of central Arizona, but smaller and of slenderer proportions; color about the same; cranial details, especially the smaller mastoids, distinctive; tail longer than head and body, slightly crested near end and tufted as in *amplus*. Distinguished from *P. a. rotundus* of southwestern Arizona, by smaller size, darker, richer pinkish buffy coloration, and less swollen mastoids. Size about as in *Perognathus amplus pergracilis* of northwestern Arizona, south of the Grand Canyon, but color distinctly darker pinkish buff; skull differing in detail.

Color.—Type (acquiring fresh pelage): Upper parts near pinkish buff (Ridgway, 1912), purest on cheeks, shoulders, flanks and outer surfaces of thighs, the top of head and back finely lined with black; under parts, fore limbs, and hind feet white; ears pinkish buffy externally, except anterior fold which is dusky, sparsely clothed internally with blackish hairs, and distinctly edged with white near posterior base; tail thinly haired, grayish above, whitish below, becoming brownish or dusky on crest and terminal tuft. Adults in somewhat worn summer pelages are of a deeper, richer color than the type, the general tone above between pinkish buff and cinnamon buff.

Skull.—Similar in general to that of *P. a. amplus*, but decidedly smaller; mastoids less inflated, the sides more convergent posteriorly (sides more nearly parallel, owing to lateral expansion posteriorly in the type of *amplus*); dentition about the same. Size much smaller than *P. a. rotundus*, with mastoids less swollen and not bulging above level of outer borders of parietals as in that form. Similar in size to *P. a. pergracilis*, but frontals broader; interparietal narrower; mastoids and dentition about the same.

Measurements.—Type: Total length, 155 mm.; tail vertebrae, 84; hind foot, 20. Average of 10 adult topotypes: 140 (123–150); 72 (60–80); 18.7 (17–20). *Skull* (type): Occipitonasal length, 23.5; greatest breadth (across audital bullae at meatus), 13.7; zygomatic breadth (posteriorly), 12.2; interorbital breadth, 5.3; length of nasals, 9.2; width of nasals (in front of incisors), 2.3; interparietal, length, 3, width, 3.2; maxillary toothrow (alveoli), 3.4.

Remarks.—Perognathus amplus as a species presents a rather unusual range of geographic variation in combination of details of form and feature, within a limited area, even for a member of a group so subject to diversification as the pocket mice. While the several races are obviously very closely allied the distinctive characters are quite constant. A specimen from Gila Bend is somewhat larger and in rather pale color indicates gradation toward *P. a. rotundus*. The collector found *P. a. taylori* inhabiting the "creosote" (*Covillea mexicana*) type of vegetation cover.

Specimens examined.—Total number, 27, all from Arizona, as follows: Casa Grande, Pinal County, 1; Continental (Amado Well, 2 miles south), 4; Gila Bend, Maricopa County, 1; Gunsight, Pima County, 1; Papago Well (O'Neill Hills, 8 miles east), Pima County, 1; Range Reserve (35 miles south of Tucson), 19.

ANATOMY.—*Formatio reticularis and reticulospinal tracts, their visceral functions and possible relationships to tonicity and clonic contractions.*[1] WILLIAM F. ALLEN, University of Oregon Medical School.

It is known from embryology that most of the left over cells of the brain stem and spinal cord which are not concerned in the formation of motor root nuclei and purely sensory relay nuclei are utilized in the production of the formatio reticularis. This is a very old structure phylogenetically. It is but little differentiated in the lower vertebrates, where it apparently serves as an effective mechanism which enables these animals to adapt themselves properly to their various inside and outside conditions. In the higher vertebrates there is but little reticular formation in the spinal cord, but considerable in both the median and lateral portions of the medulla, pons and midbrain, where for the most part it exists anatomically in its original undifferentiated state. Reticular formation surrounds or partially surrounds the sensory nuclei of the thalamus, and when considered phylogenetically the nucleus ruber, substantia nigra and other differentiated hypothalamic and midbrain nuclei should probably be considered as specialized derivatives.

Afferent fibers to the formatio reticularis: The hypothalamic nuclei undoubtedly receive important olfactory, thalamic, basal ganglia, cerebral, cerebellar and medullary connections. The nucleus ruber and other midbrain nuclei belonging to this system have similar connections and should be stimulated by like impulses. Ramón y Cajal has demonstrated many collaterals from the corticospinal fibers distributed to the formatio reticularis of the pons and medulla. Pavlow, Busacca, Rasmussen and Le Cocq have found many degenerated fibers in the formatio reticularis of the pons and medulla resulting from lesions in the colliculi and these degenerated fibers were not traceable in the spinal cord below the cervical region. Le Cocq has shown that transecting the spinal cord at the 6th. cervical vertebra resulted in no chromatolysis in the superior colliculi, while large lesions in the medulla were followed by many chromatolytic cells in the motor area of the superior colliculi. Hence the descending tract from the superior colliculus is to be regarded as tectobulbar rather than tectospinal. Fibrae fastigiobulbares from the fastigial nucleus of the cerebellum have been described by Russel, van Gehuchten, Luna, Allen (1924) and Bernis and Spiegel going to Deiter's nucleus, where some probably end. A large number, however,

[1] Received July 5, 1932.

follow the descending vestibular root fibers to be distributed chiefly to the formatio reticularis of the medulla and the median longitudinal bundle. Thomas, Probst, Lewandowsky, Wallenberg, van Gehuchten, von Monakow, Luna and the writer (1924) have called attention to a descending brachium conjunctivum, which leaves the main brachium conjunctivum immediately after decussation. This tract for the most part follows dorsally to the median lemniscus and terminates in the reticular formation of the pons and medulla. Attention is also directed to the possible importance of numerous branches of the brachium conjunctivum to the hypothalamic region. These fibers were described by Probst (1901) and confirmed by the writer (1924). Van Gehuchten and the writer have found numerous branches of the brachium conjunctivum ending in the formatio reticularis of the midbrain and in the oculomotor nuclei. Presumably all of the sensory cranial nerve fibers communicate in one way or another with the reticular formation. The many vestibular connections to the undifferentiated and differentiated formatio reticularis, described by Muskens and others, should be of considerable significance. They are said to arise from the triangular, Deiter's and Bechterew's nuclei, to go by way of the posterior longitudinal bundle, and to be associated with forced movements. Muskens describes a crossed and an uncrossed fasciculus vestibulo-mesencephalicus to the interstitial and posterior commissural nuclei and an uncrossed fasciculus vestibulotegmentalis lateralis (and possibly a medialis) to the tegmentum. He also describes efferent tracts from the interstitial and posterior commissural nuclei to the medulla and spinal cord and suggests possible connections from the corpora striata to the posterior commissural nuclei. The writer's experiments (first paper 1927) indicated that fibers from the solitary tract and commissural nuclei (terminal nuclei for the sensory fibers of the VII, IX and X cranial nerves) do not go directly to the spinal cord, but are relayed by way of the formatio reticularis.

Efferent fibers from the formatio reticularis: Some of these fibers obviously synapse with the various motor root nuclei of the brain stem. According to Kohnstamm, Tschermak, von Bechterew, van Gehuchten and Papez the descending fibers from the reticular formation may or may not cross in the medulla. Van Gehuchten, Probst and Papez have described ventral and lateral reticulospinal tracts in the spinal cord. The former run in the ventral column and the latter approximate the gray in the lateral column. The reticulospinal tracts have received some attention as extra pyramidal tracts on

account of their cerebral connections. The course of the rubrospinal tract in the brain stem and lateral column of the spinal cord is well known.

Possible functions of the formatio reticularis: All physiologists agree that the medulla contains centers for altering the rate of the pulse and the level of blood pressure. Ranson and Billingsley have located vaso constrictor and vaso dilator points in the medulla not far from the area postrema. Transecting the spinal cord in the upper cervical region greatly reduces arterial pressure for some time. Many investigators including Brown-Séquard, Gad and Marinesco, Kohnstamm and others have placed the medullary respiratory center within the limits of the formatio reticularis. Lumsden has located 3 different respiratory centers in the medulla and pons, the stimulation of which affects respiration differently. Spiegel and Enghoff place the respiratory center in the rhombencephalon. They state that stimulation or injury to this center results in the Cheyne-Stoke or Biot type of respiration. Other regions such as corpora quadrigemina, nucleus ruber and tegmentum which may produce an arrest of respiration from stimulation are considered only as reflex areas.

Many investigators from Karplus and Kreidl to Beattie have emphasized the importance of certain hypothalamic nuclei as centers for visceral and humoral impulses. Beattie thinks this area has both sympathetic and parasympathetic centers. The following investigations also demonstrate that lower levels of the formatio reticularis may have like functions: Spiegel and Démétriades have observed that intestinal movements caused from vestibular stimulations were intensified after transecting the midbrain. Ingram, Ranson and Hannet obtained pupillary dilation from stimulation of the reticular formation of the mesencephalon and pons. The writer (1931) showed that the slowed pulse followed by a bigeminal pulse, the rise in blood pressure and the arrest of respiration caused from stimulation of the trigeminal nerve by insufflation could readily be evoked when the brain stem was sectioned below the diencephalon. In addition there was probably an increased output of adrenalin. The writer's work (1927 and 1931) indicates that the respiratory and vascular changes elicited from stimulation of the cerebral motor cortex and the superior colliculus are not conducted within the spinal cord by the pyramidal and rubrospinal tracts or by a "tectospinal tract" from the colliculus, but by relays to the reticulospinal tract. It was further demonstrated (second paper 1927) that the well known rigidity and clonic contractions elicited from stimulations of the superior colliculus were depend-

ent on the integrity of the median portion of the lateral columns of the spinal cord as well as the ventral columns, a region traversed by the reticulospinal fibers.

Possible relationships of the formatio reticularis to the cerebellum and to muscle tone: In Luciani's classical experiments of removal of one half of the cerebellum, the second stage was described as one of marked weakness on the side of the lesion. Ingvar has reported that destruction of the anterior lobe of the cerebellum results in a tendency for the animal to fall forward, while obliteration of the posterior lobe causes the animal to fall backward; and a lesion in one hemisphere is followed by a tendency to fall to that side. Miller and Laughton have shown that faradic stimulation of the basal nuclei of the cerebellum of a decerebrate animal (red nucleus intact) increases the tone of the flexor muscles and decreases the tone of the extensors and is followed by a rebound. Several years earlier Bremer obtained similar results from stimulation of the palaeo-cerebellar cortex. In addition he obtained an alteration of certain rhythmic movements of progression which may be present in decerebrate animals. Some unreported experiments by the writer have shown that injection of a few drops of sodium citrate into the cortex of the cerebellum evokes rigidity and clonic contractions of the limbs that are very similar to the convulsions produced from faradic or citrate stimulation of the superior colliculus. It has been demonstrated by Magnus and others that removal of the cerebellum in a decerebrate rigid animal does not alter the tone. This, however, does not necessarily mean that the cerebellum is not concerned with or may not alter muscle tone. In fact, Sherrington, Loewenthal and Horsley, Bremer, Miller and Banting have shown that weak faradic stimulation of the cortex of the vermis (palaeo-cerebellum) in decerebrate rigid animals inhibits this rigidity.

Concerning the two efferent pathways from the cerebellum to the formatio reticularis of the brain stem, the brachium conjunctivum and its main ascending division to the nucleus ruber and thalamus have generally been associated with muscle tone, but its descending division and its many endings in the formatio reticularis of the pons and medulla have apparently been entirely ignored in this connection. This important descending tract may be intact in many decerebrate rigid animals. The fastigiobulbar tract has received some consideration as a muscle tone pathway by Bernis and Spiegel and by Miller and Laughton. The former also called attention to the importance of fibers in the fastigiobulbar bundle that originate from the cortex of the vermis.

To the writer the afferent connections to the formatio reticularis from the cerebrum, colliculi, corpora striata, and especially the diverse and extensive connections from the cerebellum suggest that considerable portions of the formatio reticularis function as efferent centers for tonic impulses. It may be that there are separate areas for inhibition as well as for augmentation. The usual explanation of the experiment of Magnus, where the decerebrate rigidity which resulted from transection of the brain stem below the nucleus ruber did not disappear with successive transecting of the medulla caudally until a level was reached directly below Deiter's nucleus, is that this section excluded all of Deiter's nucleus. On the other hand, it might be explained that the section below Deiter's nucleus eliminated all or practically all of the connections of the formatio reticularis of the brain stem.

The extensive distribution of the reticular formation through the brain stem and spinal cord may be used to good advantage in the "summation" and "recruitment" phenomena.

SUMMARY

Considerable evidence has accumulated in support of the formatio reticularis containing the chief visceral effective centers of the brain stem, which if true, would make the reticulospinal tracts the main pathways for effective visceral impulses in the spinal cord. There are also indications that this system may be associated with tonic impulses and clonic contractions. It is not the intention of the writer to minimize the importance of the hypothalamic nuclei as visceral motor centers, but rather to emphasize other equally important visceral effective areas in the formatio reticularis at lower levels.

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SCIENTIFIC NOTES AND NEWS

FREDERICK BATES, Chief of the Polarimetric Section of the Bureau of Standards, has recently returned from a tour of European laboratories. He was elected President of the International Commission for Uniform Methods of Sugar Analysis which was reconvened at Amsterdam, Holland, the week of September 5th, 1932. Approximately 50 delegates were present. Practically all of the major countries interested in scientific development were represented. A number of important international agreements on methods of scientific procedure were obtained and plans laid for much additional research through international cooperation.

CURTIS P. CLAUSEN of the Bureau of Entomology, formerly in charge of research work on parasites of the citrus black fly at Kuala Lumpur, Federated Malay States, has been transferred to Washington. In his new assignment, he will coordinate the work of the Bureau and cooperating States on the study, breeding, importation, and distribution of beneficial insects.

A. S. HITCHCOCK, custodian of grasses in the U. S. National Museum, has been elected a corresponding member of the Argentine Scientific Society.

GEORGE W. LITTLEHALES, head of the division of research of the Hydrographic Office of the Navy, has been retired from active duty under the provisions of the economy bill after forty-seven years of service.

HENRY S. WASHINGTON, petrologist of the Geophysical Laboratory, Carnegie Institution of Washington, has been elected an honorary member of the Mineralogical Society, London.

The 1932 directory of the Academy and affiliated societies has just come from the press. Single copies may be purchased from the Treasurer, H. G. AVERS, Coast and Geodetic Survey, at a cost of 35 cents.

Obituary

IRWIN G. PRIEST, chief of the colorimetry section of the Bureau of Standards, died suddenly on July 19, 1932. He was born near Loudonville, Ohio, on January 26, 1886. Graduating in 1907 from the Ohio State University, he came to the Bureau of Standards as a personal assistant to the director. In 1913 he was made chief of the colorimetry section. Much of the theory of interpreting spectrophotometric data in terms of dominant wave-lengths, purity, and brightness is due to him.

Mr. PRIEST was a fellow of the American Physical Society and the American Association for the Advancement of Science, a member of the Optical Society of America, the American Psychological Association, the Washington Academy of Sciences and the Philosophical Society of Washington. He served as secretary (1921–24) and president (1928–29) of the Optical Society.